Ministry of Economic Development
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CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 31 October 2003 with an application for Letters Patent number 529291 made by AUCKLAND UNISERVICES LIMITED.

Dated 8 November 2004.

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529291

Patents Form No. 4

Our Ref: WEJ504629

Patents Act 1953

PROVISIONAL SPECIFICATION

COMMUNICTION METHOD AND APPARATUS

We, **Auckland UniServices Limited,** a New Zealand company, of Level 10, 70 Symonds Street, Auckland New Zealand do hereby declare this invention to be described in the following statement:

PT043845205

COMMUNICATION APPARATUS AND METHOD

Field of Invention

This invention relates to communication systems, and has particular but not exclusive relevance to communication with or between devices supplied with power from an energised track, such as an HID/IPT (High Efficiency Inductive Power Distribution / Inductive Power Transfer) system.

Background

HID/IPT systems are very popular for many practical applications because they can work in very harsh environments as they transfer power without physical contact and are therefore tolerant of environmental hazards such as water, acids, dirt and grime, yet they themselves produce no harmful residues.

In consequence HID/IPT systems can operate in factories where they provide high reliability and immunity to paint and fumes. They can also operate in Clean Rooms where the level of cleanliness is very high and the HID/IPT system is compatible.

The ability for communication with a device powered by an HID/IPT system is becoming increasingly important. HID/IPT systems usually transfer power to devices that have a task to perform, for example the devices may be carriages which perform automated processes or which are required to travel to a selected location. The tasks that the devices are to perform can be automated to a greater degree and made far more efficient by providing a means of communication between devices and/or between each device and a system control module.

A communications system for an HID/IPT system must share the same advantages as the HID/IPT system i.e. it must transfer information without physical contact and must be tolerant of a harsh environment yet produce no residues, or electromagnetic interference, itself.

HID/IPT systems operate in a wide range of environments where the power cables of the primary conductive path or track may be in air, or water, or even concrete. In these special circumstances it is unlikely that one particular type of communications system will

be universally applicable. In a separate application a communications system where the HID/IPT track is tuned to two frequencies at the same time has been disclosed. This system has the advantages of low cost (as no additional conductors are required) and applicability, as wherever there is power there are communication signals as well. But the range of applicability of this technique is limited as the bandwidth that is available using pick-ups tuned to both a power frequency and a communications frequency at the same time is limited. In practice bandwidths of less than 50kHz are to be expected. The method has the advantage that it is operable with all HID/IPT media e.g. wood, concrete, water, and air. However, in many circumstances its bandwidth is simply too small.

Wider bandwidth communication systems use microwaves, for example adhering to standards such as IEEE 802.11a or b, but these bands are becoming congested and microwave is not acceptable by many potential users of HID/IPT systems. In factory conditions microwaves can also suffer from shadowing. This means that extra diversity must be introduced which adds to spectral clutter. Wideband systems can also use leaky feeders. These are essentially distributed antennas and radiate widely making compliance with emission standards difficult when wide bandwidths are needed. Leaky feeders are also very expensive. Other communications systems economise by using the HID/IPT cables to propagate radio signals as well and having antennas distributed around the track to receive the signals. These systems are effective but leak radiation as power wires are not good RF conductors, and consequently they have a restricted bandwidth and range.

Summary of Invention

It is an object of the present invention to overcome or ameliorate one or more disadvantages of known communication systems, or to at least provide the public with a useful alternative.

Accordingly in one aspect the invention broadly provides a communication system for a load that receives power from a conductive power supply path, the communication system including:
a conductive communication path capable of conveying communication signals, and
a communication device associated with the load, the communication device including a coupling means provided adjacent to the conductive path to couple communication signals to or from the communication device to the communication path.

Preferably the coupling means is provided in the near field of the communication path. Preferably the system allows bi-directional communication between the communication device the communication path.

Preferably essentially no power is radiated from the communication path.

Preferably the communication path comprises a cable having two conductors.

Preferably the conductors are separated by an insulating web.

Preferably the cable may comprise a ribbon cable such as a 300 ohm communication cable.

Preferably the coupling means comprises an inductance.

Preferably the inductance may comprise a partial or single turn of a conductive material.

Preferably the inductance is provided on a substrate such as a PCB.

Preferably the communication path is terminated with a resistance corresponding to the characteristic impedance of the path.

Preferably the system includes a communication device directly coupled to the communication path.

In a further aspect the invention broadly provides a method of providing communication to or from a load that receives power from a conductive power supply path, the method including the steps of:
providing a conductive communication path capable of conveying communication signals,
providing a communication device associated with the load, the communication device including a coupling means provided adjacent to the conductive path, and either

a) imposing a communication signal on the communication path and using the coupling means to provide the signal to the communication device, or

b) using the communication device to generate a communication signal and using the coupling means to provide the signal to the communication path.

In a further aspect the invention broadly provides a communication system having a conductive communication path and means to couple power into the communication path either directly or with a mutual inductance so that one or more devices associated with the communication path can communicate with each other with essentially no power being radiated from the communication path.

The invention also consists of any novel feature or combination of features described herein.

Further aspects of the invention, which should be considered in all its novel aspects, will become apparent to those skilled in the art upon reading the following description which provides at least one example of a practical application of the invention.

Drawing Description

One or more examples of applications of the invention will be described below with reference to the accompanying drawings in which:

Figure 1	is a diagrammatic illustration of a known HID/IPT system,
Figure 2	is a diagrammatic illustration of a communication system according to the invention,
Figure 3	is a diagrammatic illustration of another embodiment of a communication system according to the invention,
Figure 4	is a sketch of an inductor,
Figure 5	is a partial elevation of a cable used in accordance with the invention,
Figure 6	is an end elevation of the cable of Figure 5,
Figure 7	is a diagrammatic elevation of the inductor of Figure 4 in use relative to the cable of Figures 5 and 6,
Figure 8	is an end elevation of the arrangement shown in Figure 7, and
Figure 9	is an end elevation in cross section showing the orientation of the communication path and pick-up relative to the power conductors in an example of an HID/IPT application.

Detailed Description

Referring to Figure 1 a known HID/IPT system is shown. Such a system is described in US patent 5,293,308, the contents of which are included by reference herein in their entirety. The system includes a conductive path 1 that is electrically energised by a power supply 2. The path 1 may include compensation capacitors 3. A device 4 is supplied with power from the path 1 by being selectively coupled to the path. Thus the device 4 has a tuned pick-up circuit 5, rectifier bridge 6 and control components as described in US 5,293,308 to provide power as required by a load. The load supplied will vary upon the application of the system, and may for example be a light, or an electric motor. In many applications the path 1 will be provided along a rail or track on which bodies such as carriages are provided, and the load will include an electric motor which moves the carriage along the track.

As discussed above, communication with or between devices 4 is important to the operation and efficiency of such systems. For example, if the carriages are used to move articles through a manufacturing process area, it is important to know where each carriage is to avoid collisions or to correctly synchronise the manufacturing process. Communication can be used to allow each carriage to report its position.

The present invention provides a communication system where IPT concepts may be applied to allow communication between devices. Referring to Figure 2, an example of the communication system is shown having a communication conductive path 10. A communication device 12 may transmit or receive (or both) signals in the form of electrical energy to or from the path 10. The device 12 includes an inductance L which is coupled to path 10 by mutual inductance M.

In Figure 2 a communication signal transmitter or receiver 14 (a 50-Ohm device in this example) is directly coupled to the path which comprises a transmission line having a 300-Ohm characteristic impedance, such as 300-Ohm television ribbon) via a matching transformer 16. The path is terminated with a 300-Ohm resistor 18.

An alternative arrangement (using like reference numerals to designate like features) is shown in Figure 3. The path in this example is terminated at both ends with resistors 18 corresponding to the characteristic impedance of the cable that provides path 10, and two communication units are coupled to the path so that the path allows communication

signals to be transmitted/received between the units 12.

Conventional 2-wire transmission lines, such as the 300 – Ohm ribbon cable described above are effective at propagating VHF and UHF signals with very little loss of signal over large distances, for example 100 metres or so. Such ribbon looks like a HID/IPT track and we have found that near-field antennas can be used to insert or extract signals from the 300-Ohm ribbon. The near field antennas are in the preferred form small mutual inductances that couple an inductance L to the path 10. The mutually coupled near-field antennas are physically small so that they themselves do not radiate. In practice this condition is easily met. The mutual inductance so formed is small – of the order of 10 nH – but at these frequencies (e.g. 300 MHz) the radian frequency ($2\pi f$) is high (in the order of 2×10^9) so that the product ωM is a quite reasonable value (in this example 20 Ohms).

We have found that a 300-Ohm ribbon HID/IPT system behaves in a very similar manner to a 10-20kHz HID/IPT system. However there are also significant differences. In both systems power is introduced at one end of the cable and may be extracted by pick-ups placed or moving along the track. The conventional track is terminated by a short circuit and at regular intervals along a (long) track compensation capacitors must be placed to prevent the driving voltage from becoming too high. The 300-Ohm ribbon cable is terminated in its characteristic impedance so no compensation capacitors are required. It is not practical to terminate the conventional HID/IPT system in its characteristic impedance as the power losses would be too high – for a track with a track current of 80 A and a characteristic impedance of 180 Ohms the losses in a terminating resistor would be 1.15MW and the operating voltage would be 14.4kV. These differences apart, we have found that the two systems behave almost identically. Pick-ups with the 300-Ohm ribbon cable are very simple AC (RF) devices and are fully reversible. They do not require decoupling as they do not have to be tuned and they place very little load on the track. Their reversibility is a major advantage.

In practice a pick-up in the 300-Ohm system is a small single turn inductor (although those skilled in the art will realise that other physical arrangements may be used such as a partial turn or more than one turn) with a shape that is preferably rectangular as shown in Figure 4. In that Figure, the long side 20 of the rectangular shape may be 40mm for example and the short side 22 may be 10mm. The inductor may be formed using a PCB

so that the majority of the conductive surface of the original board is etched away to leave the generally rectangular conducive strip. The inductor so formed is connected to the communication device, for example by a coaxial cable 24.

Turning to Figures 5 and 6, a portion of ribbon cable is shown, generally referenced 30, having two conductors 32 that are spaced approximately 10mm apart being separated by an insulating web 34.

In Figures 7 and 8 the typical disposition of the inductor L relative to the ribbon cable is shown. A side 20 of the inductor L is placed parallel to, and in close proximity (e.g. 5mm – 10mm) with one of the conductors 32 of the ribbon. The inductor L and the ribbon are preferably in the same plane. This pick-up would have a self-inductance of around 40nH and a mutual inductance to the track of approximately 10 nH. If the pick-up is truly in the near-field then simple circuit theory may be used to calculate its performance. With the dimensions given as above and with a ribbon terminated in 300 Ohms at both ends the calculated loss from one pick-up driven by a 50 Ohm generator to another pick-up is 49.5 dB; the measured loss in the same circumstances is 51 dB. Similarly if the ribbon is driven with a matching transformer to match 300 Ohms to a 50 Ohm generator the calculated loss from the generator to the pick-up is 28 dB against a measured loss of 31 dB. For propagation in the opposite direction from the pick-up to the generator the figures are again 28 dB and 31 dB.

In Figure 9 a diagrammatic cross section is shown through a rail assembly 40 of an IPT system installation. The rail supports the track or primary power conductors 42 which are arranged to allow passage of a power pick-up core 44. The communication conductor 10 (comprising ribbon 30) is shown provided on the rail assembly, and the inductor L is shown in close proximity to the ribbon, being supported by an arm 46 from the core so as to move with the core if necessary.

In an HID/IPT system the effect of a loaded pick-up is to reflect an impedance back into the track. Thus a 3 KW load reflects a resistance of 0.469 Ohms back into a track with 80 A in it to produce the 3 kW (assuming no loss). Similarly the 300-Ohm ribbon also has a reflected impedance of approximately 0.7 Ohms induced in it – this is small compared with the characteristic impedance and has very little effect on the propagation of signals in the ribbon. With the ribbon a pick-up sending power to the ribbon also sees a back-reflected impedance – again of 0.7 Ohms – this is small and even though it is a mismatch it has

very little effect on the performance of the pick-up or the ribbon.

From the foregoing it will be seen that an effective solution is provided to the problem of communications in IPT systems. Those skilled in the art will see that the communication system of the invention may also be used in non-HID/IPT applications, for example applications where vehicles or other bodies are powered by electrical and physical contact with a conductive path.

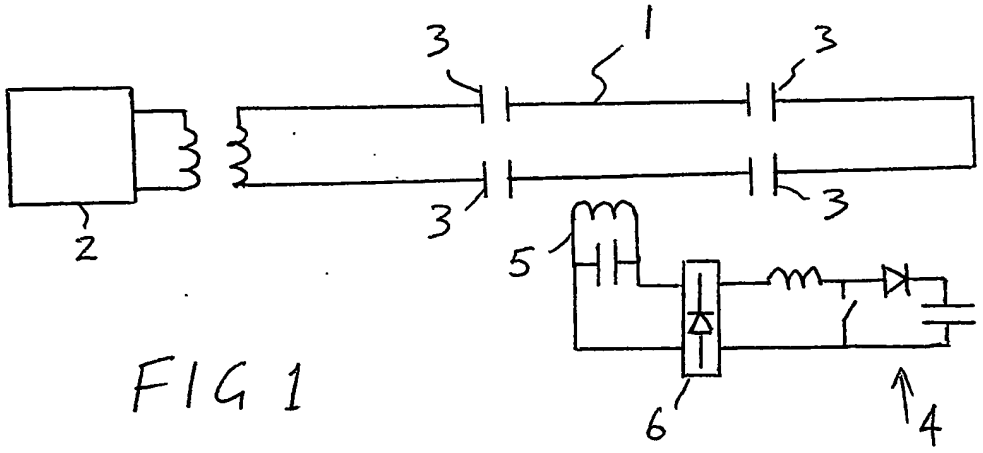

FIG 1

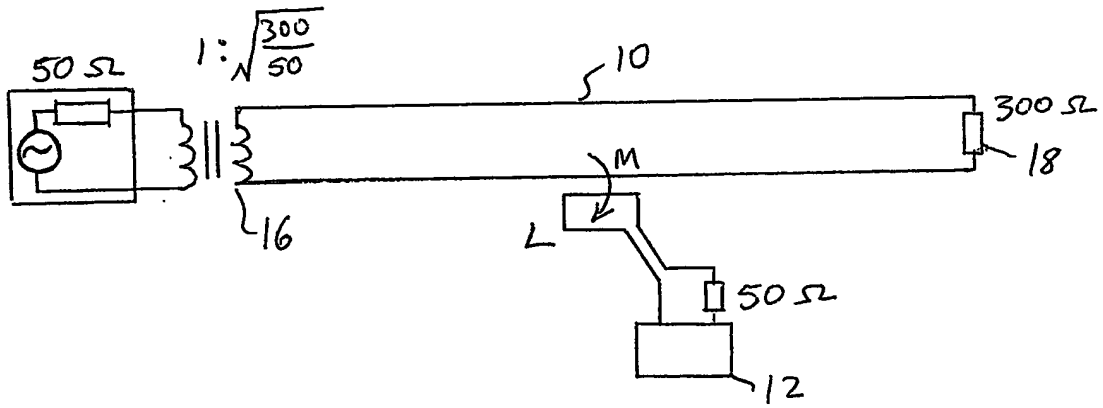

FIG. 2

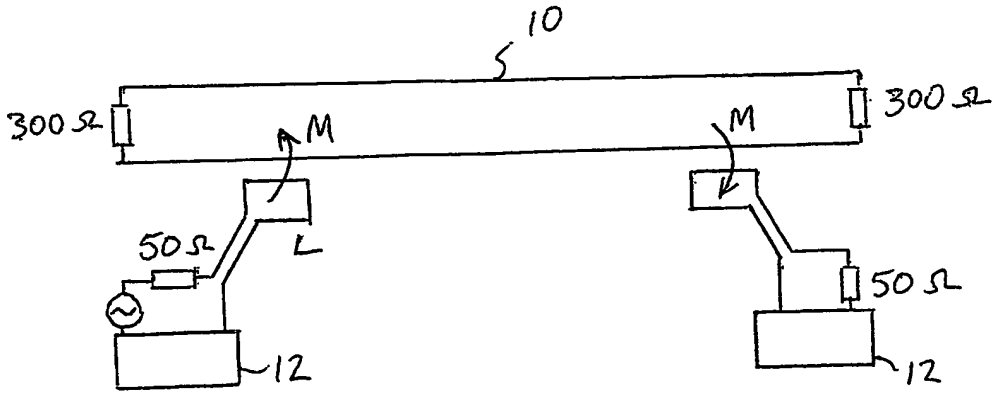

FIG 3

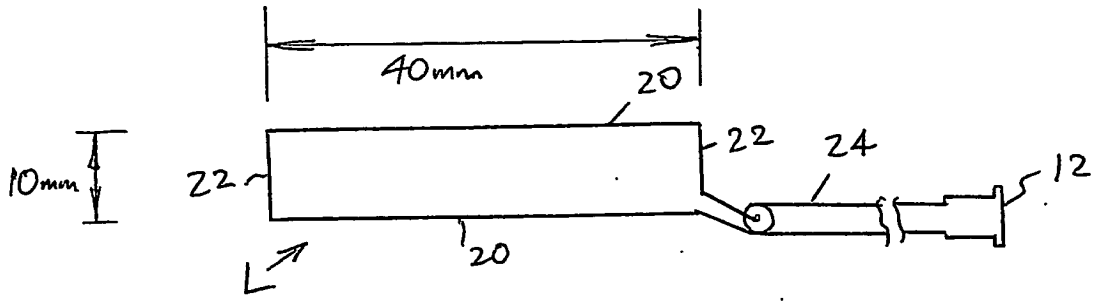

FIG 4

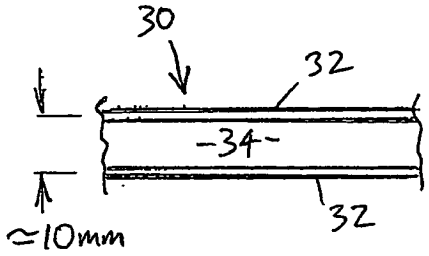

FIG 5

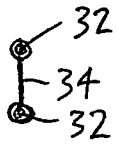

FIG 6

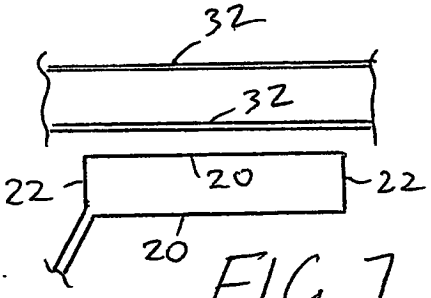

FIG 7

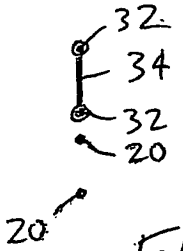

FIG 8

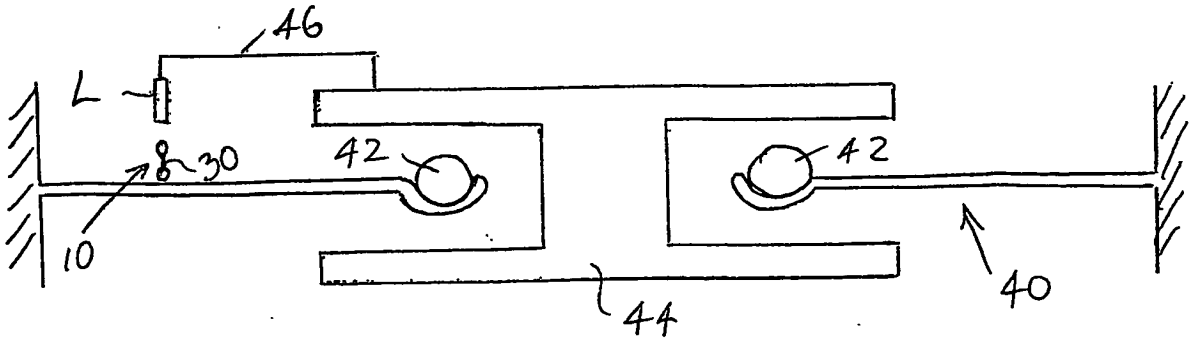

FIG 9